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Fiscal Federalism and Tax Equalization: The potential for progressive local taxes

Debra Hevenstone[+] and Ben Jann[*]

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Abstract:

We construct an empirically informed computational model of fiscal federalism, testing whether horizontal or vertical equalization can solve the fiscal externality problem in an environment in which heterogeneous agents can move and vote. The model expands on the literature by considering the case of progressive local taxation. Although the consequences of progressive taxation under fiscal federalism are well understood, they have not been studied in a context with tax equalization, despite widespread implementation. The model also expands on the literature by comparing the standard median voter model with a realistic alternative voting mechanism. We find that fiscal federalism with progressive taxation naturally leads to segregation as well as inefficient and inequitable public goods provision while the alternative voting mechanism generates more efficient, though less equitable, public goods provision. Equalization policy, under both types of voting, is largely undermined by micro-actors' choices. For this reason, the model also does not find the anticipated effects of vertical equalization discouraging public goods spending among wealthy jurisdictions and horizontal encouraging it among poor jurisdictions. Finally, we identify two optimal scenarios, superior to both complete centralization and complete devolution. These scenarios are not only Pareto optimal, but also conform to a Rawlsian view of justice, offering the best possible outcome for the worst-off. Despite offering the best possible outcomes, both scenarios still entail significant economic segregation and inequitable public goods provision. Under the optimal scenarios agents shift the bulk of revenue collection to the federal government, with few jurisdictions maintaining a small local tax.

Keywords: Fiscal Federalism, Equalization Grants, Computational Modeling, Tiebout Sorting, Theory of Justice, Multi-community model

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1. Introduction

Today, most countries devolve some portion of revenue collection to sub-national level, called "fiscal federalism." States do this because fiscal federalism perceived as one potential solution to the "public goods problem." The public goods problem is the fact that there is no market for public goods, so there is no way of determining the optimal level of public goods provision nor the price. However, fiscal federalism is no panacea, as it engenders the "fiscal externality problem," in which economic segregation, regressive tax policy, and inequitable public goods provision can arise, particularly if public goods are redistributive and taxable units are mobile. One solution to this secondary problem is tax equalization.

The "multi-community" literature examines the fiscal externality problem using models of utility-maximizing agents who can move between local jurisdictions offering diverse tax policies and public goods. This literature suffers a few limitations. First, models exclusively consider flat taxes. This makes sense when looking only at fiscal federalism, absent equalization, as the problems associated with redistribution are clear. However, the fact is that local taxes are often progressive. Given this reality, when testing the potential of equalization to overcome the fiscal externality problem, progressive taxation must be considered. Second, models of fiscal federalism and equalization use almost exclusively median voter models. While this is an important theoretical baseline, it is not an accurate reflection of the policy making process, potentially generating unrealistic policy implications. Furthermore, its inaccuracies are exaggerated in an environment with progressive taxation. Finally, those models specifically examining equalization have, to date, been unable to show whether equalization can overcome the fiscal externality problem.

In this paper we answer a few questions. First, we confirm that fiscal federalism with local progressive taxation generates residential segregation, inefficient public goods provision, and inequitable public goods provision. At the same time, we validate the model, showing that results closely match empirical conditions in Switzerland. Second, we ask whether results are different using a more realistic voting mechanism. Third, and finally, we examine whether vertical or horizontal equalization could solve these problems, despite their known unintended consequences with respect to the over-provision of public goods in poor jurisdictions and the under-provision of public goods in wealthy jurisdictions, respectively.

2. Literature and Hypotheses

This section offers a general introduction, reviews the multi-community literature, and poses hypotheses. The first sub-section focuses on fiscal federalism generally while the second subsection focuses on equalization.

2.1. Fiscal Federalism

2.1.1. Background

Fiscal federalism is often proposed as a solution to the public goods problem. The public goods problem is that there is no market for public goods with no clear optimal quantity or price. Individuals have no incentive to reveal their preferences (and pay accordingly) because understating preferences allows them to free-ride. For example, one might claim to derive no value from one's town July Fourth fireworks, but nevertheless enjoy them from one's back yard. Furthermore, the state, as a monopolist provider, has an incentive to under-provide and over-charge for

public goods. Fiscal federalism has been traditionally seen as one potential solution to these problems (Musgrave, 1939; Buchanan, 1950; Samuelson, 1954; Musgrave, 1959; Arrow, 1970).

The basic mechanisms at work under fiscal federalism might be phrased using the language of the classic "Exit, Voice, and Loyalty" (Hirschman, 1990). Hirschman proposed that institutions change through market forces ("exit") or direct influence ("voice"), with the ratio between the two depending on individuals' "loyalty" to the institution. Under fiscal federalism, "exit" is the household's choice to move, while "voice" is how residents exert their preferences on policy decisions. Exit is also the mechanism at work under the well-known "Tiebout Hypothesis," which posits that residential choice can work as a market for public goods (Tiebout, 1956). There is empirical evidence for these two mechanisms. Policy has been shown to influence residential decisions, though the association is limited to certain groups (e.g., the wealthy or young college graduates) and moves are more likely to be inter-municipal than inter-state (Peterson and Rom, 1990; Schmidheiny, 2006; Liebig et al., 2007; Banzhaf and Walsh, 2008). "Loyalty" (e.g., social networks or familiarity) is one reason for this attenuated link (Feld and Kirchgssner, 2000; Frey and Carlson, 1996). There is also empirical support for the idea that residents' preferences are correlated with local policy and spending choices (Matsuka, 1995; Feld and Kirchgassner, 2001). Exactly how these preferences translate into policy is uncertain; often a median voter model is used as as a rough approximation, despite evidence that policy does not even reflect the median voter's preferences under direct democracy—an environment that should reflect the median voter model if any did (Milanovic, 2000; Noam, 1980). One likely reason is that the wealthy (and/or the more educated) have the time to take part in politics, the money to contribute to campaigns, and the skills to use their time and money effectively, thus exerting more power (Verba et al., 1995; Page et al., 2013; Stolle and Hooghe, 2009).

The two mechanisms, exit and voice, ultimately lead to the "fiscal externality problem." The fiscal externality problem arises when jurisdictions choose their taxes or regulation policies independently, resulting in a severe loss for everybody if the taxed factor is mobile. This implies that there should be no income taxation if those paying income tax can easily move. In the worst case, high earners continually move to the lowest tax rate jurisdiction with tax rates falling as jurisdictions compete for tax payers, ultimately leading to the under-provision of public goods.

Because of the fiscal externality problem, redistributive local financing or policy is considered particularly inadvisable given a mobile population with heterogenous resources. Redistributive public goods or progressive funding generate incentives for the wealthy to form enclaves leading to segregation, regressive tax policy, and inequitable public goods provision (Oates, 1999; Boadway and Shah, 2007; Inman and Rubinfeld, 1996; Oates, 2005; Zeng, 2008; Schmidheiny, 2006; Dowding et al., 1994; Howell-Moroney, 2008; Hanushek and Yilmaz, 2007). For this reason, it is generally agreed that local governments should raise revenue using benefit taxes and user fees (Oates, 1999, 2005). However, the reality is that local taxes are not always flat. While US state taxes are often flat (Davis et al., 2009), many countries use progressive local taxes (e.g., Swiss cantonal and municipal income taxes are obliged to be progressive by the constitution and the UK council tax has progressive property tax bands). The reason for this is that the general public does not support flat taxes, as evidenced by the poll tax riots in the UK, that ultimately contributed to the fall of the Thatcher government (Smith, 1991). One additional problem is that even with flat taxes, it can plausibly be argued that *all* local public goods are inherently redistributive, as even with a flat tax funding a good consumed by most citizens (such as schools) the wealthy still pay more in absolute terms (Boadway and Tremblay, 2012).

2.1.2. Multi-community literature

The literature on the "multi-community model" examines exit and voice mechanisms under fiscal federalism. Investigated equilibrium outcomes are economic segregation and the equity and efficiency of public goods provision. Traditionally, the multi-community literature has used analytical models, though the inferences available using such an approach are limited insofar as public goods provision under fiscal federalism (as many economic phenomenon) is a process occurring not only at the individual level, but also in response to endogenous macro level phenomenon (Arrow, 1994). In recent decades the response to this limitation has been to use computational models in addition to analytic models (Nechyba, 1996). Both types of models face important trade-offs in their design with respect to parsimony and realism. Here we will briefly outline some "best practices" from this literature, point out two key holes, and then summarize findings.

One key model design choice has to do with agent heterogeneity. Agents can be heterogeneous in their preferences or in resources. Studies focusing on the Tiebout Hypothesis tend to use agents with heterogeneous preferences but homogenous resources (Kollman et al., 1997) while those focused on the fiscal externality problem use agents with heterogeneous resources but homogeneous preferences (Epple and Romer, 1991; Hindriks and Myles, 2003; Kessler et al., 2011; Nechyba, 1996; Penn, 2004). Models examining the trade-offs between the two use heterogeneous preferences *and* incomes (Ferreyra, 2009; Kessler and Lulfesmann, 2005; Calabrese et al., 2012). Heterogeneity can be limited to dichotomous categories or continuous variables (Hanushek and Yilmaz, 2007). This choice matters, as the relative variability of preferences versus incomes has been shown to dictate whether efficiency (the Tiebout hypothesis) or equity (the fiscal externality problem) dominate (Kessler and Lulfesmann, 2005).[1] Given this finding, models should include both income and preference heterogeneity, basing distributions on empirical evidence. By doing otherwise, model outcomes reflect model assumptions rather than the conditions being tested.

A second key design choice is how to treat housing. Some models consider jurisdictions as boundless, while others limit housing stock (Kessler et al., 2011; Calabrese et al., 2012), with unlimited housing stock more likely to generate perfect economic stratification. When housing stock is limited, housing prices can then be set endogenously, such that they capture the value of living in a jurisdiction (de Bartolome and Ross, 2007). This is an important intermediate mechanism in generating the fiscal externality problem that should not be excluded (Kessler et al., 2011).[2] In sum, models should limit housing stock and include an endogenous housing market.

There are two significant holes in the multi-community literature. The first has to do with progressive taxation. Because of the aforementioned problems with redistribution under fiscal federalism, studies use flat taxes (e.g., head taxes (de Bartolome and Ross, 2007), property taxes (Calabrese et al., 2012), or income taxes (Hindriks and Myles, 2003)). Some researchers compare results using different types of flat taxes (Calabrese et al., 2002) or consider scenarios in which agents can choose between them (Nechyba, 1997).[3] Limiting analysis to flat taxes makes sense in basic models of fiscal federalism. However, the fact is that many countries use local progressive taxes. Given this fact, progressive taxes need to be included when testing *solutions* to the fiscal externality problem.

The second hole in the literature is the strong reliance on median voter models, despite evidence that policy does

[1] Some models begin with the assumption that income and preferences are correlated (Calabrese et al., 2002; de Bartolome and Ross, 2007). It is difficult to know whether this is a realistic assumption; the wealthy report different policy views, but this might be due not to an actual preference to fewer public goods, but rather to the fact they pay for the bulk of policy goods (Schmidheiny, 2006).

[2] Housing prices can be included in agents' utilities, but this is in effect double counting the value of living in a jurisdiction through both public goods consumption and then through housing (Epple and Romer, 1991; Calabrese et al., 2002, 2012). These utility equations are generally linear (Calabrese et al., 2002) or Cobb Douglas (Epple and Romer, 1991). There is no clear evidence as to which is more realistic.

[3] One exception is Bolton and Roland (1997), which considers progressive taxation, looking at how economies of scale and local control impact the probability of political secession.

not reflect median voter preferences, even under direct democracy. It has been speculated that one reason for this preference in the literature is that voice can take on so many diverse forms, it is difficult to chose an alternative to the median voter model (Dowding, 2000). The median voter model has been a success insofar as it can reproduce real residential and public policy patterns (Epple et al., 2001), but the choice is not benign insofar as it by definition generates inefficient equilibria (Calabrese et al., 2012). Given these facts, the median voter model is an important baseline, but other voice mechanisms must also be explored.

The multi-community literature has made some important findings to date. Results are always examined at "equilibrium." There are two different definitions of equilibria. First, there are micro equilibria where individual agents no longer move (Calabrese et al., 2002). However, in those studies using simulation such micro-equilibria might only be achievable under very strict assumptions about communities and agents (Westhoff, 1977) or only when using flat head taxes rather than income taxes (Boadway and Tremblay, 2012). When micro-equilibria are unachievable, studies focus on macro-level equilibrium, in which no jurisdiction can change its policy and be better off, given the other jurisdictions' policies (Hindriks and Myles, 2003). At these macro equilibria, the literature has found that fiscal federalism (with property or income taxes, exit and voice, and agents heterogenous on income and preferences), tends to generate inefficient and inequitable public goods provision, often with perfect economic segregation (Calabrese et al., 2002; Kessler et al., 2011; Kessler and Lulfesmann, 2005; Calabrese et al., 2012; Epple and Romer, 1991; de Bartolome and Ross, 2007). These negative outcomes can be attenuated by introducing loyalty to place (Hindriks and Myles, 2003; Bloch and Zenginobu, 2015; Ferreyra, 2009; Nechyba, 1997; Hanushek and Yilmaz, 2007).

2.1.3. Hypotheses

The existing literature has ignored the possibility of progressive income taxes and voice mechanisms other than the median voter model. Given existing research we would expect that introducing progressive taxation *H1a: Fiscal federalism with local progressive taxation generates residential segregation, sorting by preferences, and inequitable public goods provision.* Introducing a new voting model, we need to consider potential effects on efficiency and equity. We already know that the median voter model generates suboptimal equilibrium because it is not utility maximizing. With respect to equitable public goods provision, generally a median voter model should offer greater equity than a more realistic voting model. However, when tax payers are mobile and inequality high, a median voter model could also generate greater incentives for the wealthy to segregate, ultimately decreasing equity. These two effects might well balance out. As such, using a new mechanism in which voting (or voice) is weighted by utility, we would thus hypothesize *H1b: With utility-weighted voting, public goods provision is more efficient and equally equitable.*

2.2. Equalization

2.2.1. Background

Fiscal equalization is one way to account for the fiscal externality problem, as well as a way to guarantee equitable public goods provision across regions with diverse resources (Inman and Rubinfeld, 1996; Brennan and Buchanan, 1980; Hansjörg et al., 2007; Boadway and Shah, 2007; Howell-Moroney, 2008; Cai and Treisman,

2004).[4] Equalization is widespread. In the OECD countries an average of 2.3% of GDP is spent on equalization schemes, with equalization playing a larger role in those countries with dramatic regional inequalities (Blochlinger and Charbit, 2008) including Canada, Switzerland, Australia, Belgium, and Germany. These transfers are controversial and have provoked multiple secession movements such as Flanders in Belgium, or Catalonia in Spain. The US only briefly (1972 to 1986) had an equalization scheme (the "Revenue Sharing Scheme") and today most equalization is through specific matching or block grants like Medicaid or TANF.

One might classify equalization schemes into two broad classes. "Horizontal" grants, which directly pass money from jurisdictions with more resources to those with less, versus "vertical" grants, which pass money from the central government to jurisdictions. At the same time as solving the fiscal externality problem, equalization has the potential to introduce new inefficiencies and inequities (Besley and Coate, 2003). Horizontal grants tend to incentivize the under-provision of public goods in wealthier localities that contribute (Hansjörg et al., 2007; Dahlby and Warren, 2004; Hansjörg et al., 2007) while vertical grants incentivize the over-provision of public goods in poorer receiving jurisdictions (Rodden, 2002, 2003; Keen and Kotsogiannis, 2002; Wurzel, 2003). When choosing the extent of equalization, one needs to balance concerns about equity with these potential negative effects.[5]

2.2.2. Multi-community literature

The multi-community literature focusing on equalization seeks to answer whether equalization can solve the fiscal externality problem. To date, it has been illustrated that micro actors can generate a demand for redistribution with an efficiency-enhancing effect. However, these inferences are limited insofar as: 1. The model assumed unlimited housing stock which increased segregation and inflated the demand for equalization and 2. Equalization was measured using federal per capita grants—capturing more a preference for central taxation than "equalization" per se (Epple and Romer, 1991). Other work has shown that equalization can be undermined by micro-dynamics of moving, particularly as equalization increases. However, this work was limited by the fact that models excluded preference heterogeneity, thus ignoring potential efficiency gains and exaggerating the fiscal externality problem (Nechyba, 1996). A third limitation that has been acknowledged in this literature is the exogenous treatment of housing (Ferreyra, 2009), which likely reduces the fiscal externality problem and thus artificially reduces demand for equalization (Kessler et al., 2011). Recent work has taken a more sophisticated approach, incorporating endogenous housing markets along with heterogeneous preferences and incomes and more realistic equalization payment structures (Hanushek and Yilmaz, 2007), sometimes even incorporating empirically-based heterogeneous preferences and incomes (Ferreyra, 2009). These models have the potential to answer the posed question. However, this work has focused on education, a special public good with particularly strong peer effects. The inclusion of these peer effects enhances the fiscal externality problem, likely leading to an under-estimate of equalization's potential. In sum, because of unrealistic assumptions or application to specific public goods, the existing literature cannot yet answer the question of whether equalization can overcome the fiscal externality problem.

As is the case in the standard multi-community model, progressive taxation and voice mechanisms beyond the

[4] See Boadway and Shah (2007) or Hansjörg et al. (2007) for a full description of intergovernmental transfers, and Bednar (2009) for an excellent discussion of practical design issues. Beyond equalization, there are other solutions. Matching grants are similar to equalization but with money targeted to certain goals and requiring local contributions. "Piggy-back" taxation schemes (Inman and Rubinfeld, 1996), where the central government sets a progressive tax and the local governments raise revenue by shifting the tax curve parallel and upward, is another solution. The federal government can also regulate subnational tax structures, for example making regressive taxes illegal or setting ceilings on local taxation. In the municipal context, there are suburb to city fiscal assistance and urban user fees.

[5] Loyalty can interact with these unintended consequences. When people are mobile, there is a greater problem with underspending under horizontal equalization while when they are immobile, overspending becomes more of a problem with vertical transfers (Keen and Kotsogiannis, 2002).

median voter model are ignored. The first omission is particularly egregious when considering equalization. When considering the simple case of fiscal federalism, it is known that local progressive income taxes exacerbate the fiscal externality problem. However local progressive income taxes exist. This means models testing the potential efficacy of equalization need to consider it. Relying exclusively on a median voter model compounds this problem. The median voter has a greater incentive to extract resources from the rich, generating a greater incentive for economic segregation and thus a greater need for equalization. This paper builds on the existing literature by filling these two holes, and in addition, designing a better baseline model, that will allow us to answer whether equalization can improve the efficiency and equity of public goods provision under fiscal federalism.

2.2.3. Hypotheses

Given the multi-community literature's findings we might make several hypotheses about the potential for equalization to overcome the fiscal externality problem in a context with progressive taxation. First, given evidence that agents' ability to move can counteract equalization policy, we would expect *H2a: Equalization can only partially mitigate the negative side effects of fiscal federalism, as micro-actions can counteract policy.* Considering the shown limitations of both vertical and horizontal equalization we would also expect that *H2b: Increasing horizontal equalization will reduce wealthy jurisdictions' public goods provision, while increasing vertical equalization will increase public goods provision in poorer jurisdictions.* Finally, when using the utility-weighted voting mechanism (where the rich have more political power) equalization might have to counter a smaller fiscal externality problem (due to less between-jurisdiction inequality) and the wealthy will show less support for equalization. As such, we anticipate that *H2c: equalization does not improve the equity of public goods provision under utility-weighted voting.*

The next section introduces the model, followed by sections discussing results and then the conclusion.

3. The Model

We construct a computational model of fiscal federalism integrating empirical data. An overview of the computational model is provided in Figure 1. There are three actors: households, jurisdictions, and a central government. Before the simulation begins 9,000 households are assigned incomes, public goods preferences, and a random house on a 100 by 100 grid. Income and preference distributions are based on Swiss data, which has a similar income distribution and level of public spending as in most western countries. Sixteen jurisdictions are assigned 625 housing units each and two parameters defining their maximum tax rates and tax progressions. The function controlling tax curves is based on the Swiss case, where local taxes are obliged to be progressive, resulting in a single standard tax formula controlled by just two parameters. Finally, the central government is also assigned two tax parameters controlling maximum rates and progression. Equalization policy is set exogenously by the experimenter. The simulation then begins. Households (having utilities based on private and public consumption) are given the chance to move and to vote on tax parameters at both the local and federal levels. Local and federal governments then set the new tax rates, and if an equalization scheme exists, equalization payments are processed. The cycle then repeats. The simulation is run until a macro-equilibrium is reached in which tax rates and patterns of segregation stabilize. The rest of this section describes the model in greater detail.

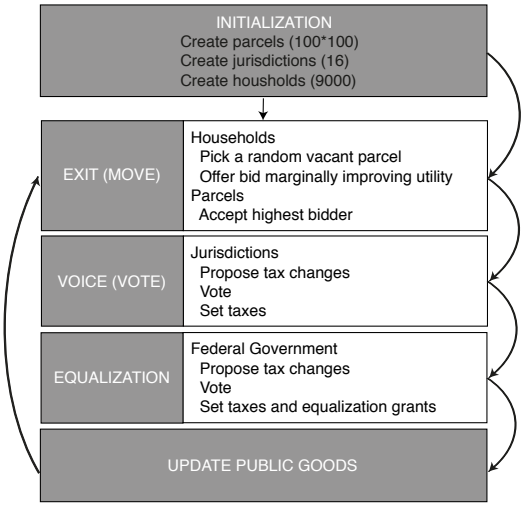

Figure 1: Model Design

3.0.1. Household Characteristics

There are two exogenous variables in the model: agents' incomes and preferences. Income is heterogeneous across agents and assigned using a lognormal distribution with parameters matching the Swiss empirical income distribution.[6] The second exogenous variable, public goods preferences, cannot be directly set using empirical data. In fact, much of economics and public finance deals with the problem of revealing people's public goods preferences, and the theoretical "Lindhal" prices that would appropriately charge people based on their demand for public goods. We used a back of the envelope calculation to generate an "empirically informed" preference distribution. First, we assumed a normal distribution, and then tested various means and standard deviations, and ran the simulation. This resulted in a simulated distribution of public goods, which could be compared with the percent of national income going to taxes. Ultimately, a standard deviation and mean were chosen based on the distribution of simulated public goods matching the real-world percent of income going to taxes. For the presented models the chosen preference distribution has a mean of .2 and a standard deviation of.05. The left-hand side of Figure 2 illustrates the percent of income going to public goods across all simulations using these preference parameters.[7] Income and preferences for public goods are not correlated.[8]

The final household level feature is household utility, as illustrated in equation 1.

[6] A lognormal distribution fits the bulk of the income distribution well, but tends to under-estimate the right hand tail of income which is better fit by a Pareto distribution. Empirical literature suggests multiple fits are possible including the Weibull, hybrid exponential decay with power decay, (generalized) beta, and gamma distributions (Singh and Maddala, 1976; Nirei, 2004; Bandourian, 2000; Salem and Mount, 1974; McDonald, 1984). The Swiss income distribution has a general form similar to the US and other developed economies, though somewhat less skewed than the US.

[7] In simulations, on average 20% of income goes to public goods, somewhat lower than in most European countries (Fiorito and Kollintzas, 2004).

[8] While the distribution of benefits of public goods skews towards the poor, due to demographic characteristics as well as progressive funding (Aaron and McGuire, 1970), it is generally agreed the most reasonable assumption is that everyone gets the same value per unit of public good consumed (Brennan, 1976), as backing out a preference distribution can be extremely complex, needing to take into account, for example, the municipal political process (Bergstrom and Goodman, 1973).

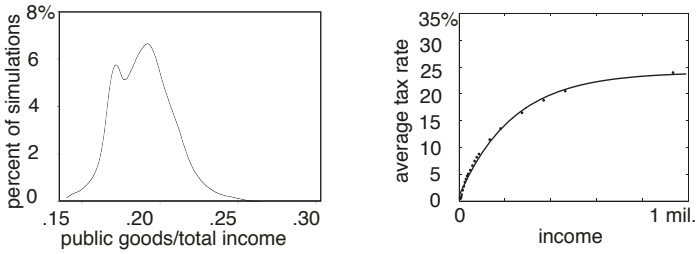

Figure 2: The distribution of public goods (as a percent of income) and fitting Zurich's tax

$$u_\ell = \underbrace{\left(\frac{g_j}{n_j} + \frac{1}{n_j}\sum_i (y_i t_i)\right)^{\alpha_\ell}}_{\text{public goods}} \underbrace{(y_\ell(1-t_\ell) - h_\ell)^{1-\alpha_\ell}}_{\text{private goods}} \tag{1}$$

where household ℓ earns y_ℓ and pays tax rate t_ℓ and housing cost h_ℓ in a jurisdiction j with n_j households indexed by i (including household ℓ). The jurisdiction receives the grant g_j from the central government.[9] Utility has a Cobb Douglas form with constant returns to scale. The first term in parentheses (raised to α) is the household's consumption of public goods and the second term in parentheses (raised to $1-\alpha$) is their consumption of private goods.The fact that revenues are simply re-divided into public goods means that the type of public good provided here is not non-rival, i.e. it is perfectly congestible. In other words, double the number of residents would double the cost of providing the public good–more akin to public schools than the military.[10] Utility is a function of the *extent* of public goods, not the *type* and assumes pure substitutability and fungibility across levels of government. This should reflect the fact that those public goods that are traditionally administered locally (e.g., schools, recreation, and housing), could still be funded centrally.[11]

3.0.2. Exit

Moving works like a simple auction. Households pick a random vacant lot, calculate the rent that would yield current utility, and then offer a bid of 1 less. Their bid is:

$$h_2 = y - t_2 y - \left(\left(\frac{p_1}{p_2}\right)^{\alpha}\left(y - t_1 y - h_1\right)^{1-\alpha}\right)^{\frac{1}{1-\alpha}} - 1 \tag{2}$$

where h_1 & h_2 are the current and potential houses' costs, t_1 & t_2 are tax rates paid living in house 1 and 2, p_1

[9] Note that all public goods are provided locally; the federal government passes all of its revenues to the local government in the form of g_j, which is described later in the section on equalization.

[10] This is an assumption that is common in the literature on local public goods (Oates, 2006) though not that taken by Penn (2004), who varied excludability as an experimental parameter in her computational model. As Oliver and Marwell (1988) point out when there is "jointness of supply," a large group size, will be advantageous by definition.

[11] Such central funding is sometimes called "administrative" versus "true" fiscal federalism (Bednar, 2009). Here, administrative fiscal federalism is simply centralization.

& p_2 are private consumption living in house 1 and 2, y is income, α is the household's preference for private consumption and $(1-\alpha)$ is the household's preference for public goods consumption. In other words, households bid such that after considering their income, taxes paid, public goods, and housing costs, their utility would be marginally higher in the new location. After each household has the chance to make one bid on a randomly selected free lot, lots are offered to the highest bidder. Housing prices are initialized at 0, and take about 4,000 ticks to stabilize. Increasing initial values does not change the equilibrium, but does decrease the time to convergence. Although housing prices are not explicitly correlated (i.e. the price of neighboring lots is ignored in bidding), prices are implicitly correlated through local policy. When two lots belong to a jurisdiction with generous public goods and low taxes, the prices of both houses are higher.

3.0.3. Voice

We set average tax rates using the formula $t_i = S(1 - e^{ky_i})$ where t_i is the household's tax rate, y_i is their income, S is a parameter measuring the maximum tax rate, and k is a parameter measuring the tax's phase-in rate. This formula could represent any progressive tax system with no discontinuities, though it was was based on Swiss tax curves; every canton sets their taxes more or less along this curve with municipal taxes "piggy-backing," that is shifting the curve up and parallel to generate revenue.[12] The right-hand panel of Figure 2 shows the tax curve for Zurich, with the dots indicating the tax table values, and the line indicating the fit curve. The theoretical curve is almost a perfect fit with $k = .0000043$, such that a household earning 232,558 CHF would pay 2/3 of the maximum tax rate and S, the maximum tax, equal to .23. All the cantons are an almost-perfect fit. The government then proposes a random increase and decrease in the parameters controlling maximum tax rates and progressions. The population votes, and then the new tax is applied. There are two types of voting. First there is a median voter model, where every person has equal voice. Second, there is utility-weighted voting where one's vote is proportional to one's improvement in utility from the proposed change. Because potential utility increases with income, this generally gives the wealthy more voting power. Ansolabehere et al. (2003) has suggested that, "since campaign contributions are so closely linked to income, campaign contributions might act like weighted votes." That is exactly the approach taken here. To determine new policy, the government proposes a random increase and decrease in each of the two tax parameters. The population then votes, and if a majority over 55% goes in either direction (to allow the possibility of allowing taxes to not change), the policy is updated.

3.0.4. Equalization

There are four equalization scenarios, described in Table 1, which illustrates g_j, the jurisdiction's federal grant. In addition to this grant, each jurisdiction has r_j, locally collected revenue.

The baseline scenario is pure federalism, i.e. every jurisdiction is funded purely by local revenue. In the second scenario, there is horizontal equalization, or payments between jurisdictions accompanied by federal tax collection, with revenues passed to jurisdictions strictly on a per capital basis. In the third model horizontal equalization is replaced with vertical grants, and in the final and fourth model, there is strict horizontal equalization with no federal taxation. Horizontal grants are calculated by subtracting the jurisdiction's per capita tax capacity x_j from the national $\bar{x}$ per capita tax capacity. Capacity is the hypothetical revenue using a target tax rate (the average rate). Grants are negative when jurisdictions have above-average capacities.[13] The redistribution parameter, θ_h, varies

[12] We have not seen this formula used in the literature nor are we aware of it explicitly being used in Switzerland to develop the tax tables. That said, the formula is such a perfect fit to the tax tables, it would be rather surprising if the government were not using it.

[13] There is a consensus that capacity is a better measure than revenue, since revenue can encourage wealthy areas to reduce taxes and shift

Table 1: Jurisdictional revenue formulae under the 4 equalization scenarios

base	horizontal	vertical	horizontal NF
0	$\frac{N_j}{N}R^f + \underbrace{\theta_h N_j(\bar{x} - x_j)}_{\text{horizontal grant}}$	$\underbrace{R^f \frac{N_j(\frac{1}{c_j})^{\theta_v}}{\sum_i N_i(\frac{1}{c_i})^{\theta_v}}}_{\text{vertical grant}}$	$\underbrace{\theta_h N_j(\bar{x} - x_j)}_{\text{horizontal grant}}$

N_j is the population in j, N is the total population, R_f is total federal revenue, r_j is revenue collected in j, θ_h is the horizontal redistribution parameter, x_j is jurisdiction's per capita tax capacity, while $\bar{x}$ is the national per capita tax capacity, θ_v is the vertical redistribution parameter, c_j is jurisdiction j's relative per capita revenue ($c_j = \frac{x_j}{\bar{x}_j}$).

from 0 (pure federalism) to 1 (maximum horizontal equalization). Vertical grants are calculated using c_j, which is jurisdiction j's per capita revenue using the target tax divided by the average jurisdiction's per capita revenue using the target tax. The redistribution parameter θ_v varies from zero (federalism) to one (extreme equalization). In sum, horizontal grants are based on the difference in jurisdiction versus national tax capacity and vertical grants are based on the ratio of jurisdiction to average jurisdictional capacity. Horizontal grants are exchanged between jurisdictions while vertical grants come from the central government.[14]

3.0.5. Equilibria

The results presented here are those found at a macro-level equilibrium (i.e., at the point where individual agents might continue to move, but macro patterns (e.g. segregation and jurisdictional tax rates) stabilize).[15]

Figure 3 illustrates the convergence of segregation and tax rates (averaged across 10 simulations) using the utility-based vote, and horizontal equalization set to .3. In this simulation the maximum federal tax rate leveled out around 10%, the phase-in around -.00001 (households reache 2/3 the maximum rate at 110,000 CHF). Comparing statistics for the richest, poorest, and middle-income jurisdictions, we can see segregation set in at around the 1000th tick. The maximum tax rate was still slightly increasing for the poorest jurisdiction when the simulation stopped. The last box illustrates maximum tax rates by the jurisdiction's average preferences, showing that those

public goods consumption to the private market. The standard approach to measuring capacity (used here) is to use the average tax rates across geo-political units, applied to the income of each individual. This method weights by political unit, rather than population. This is preferred because population weighting can allow large geo-political units to manipulate the size of their grant by adjusting their tax rate; that is to say a big state with a high tax capacity that increases its tax rate reduces its grant, while a big state with a low tax capacity increases its grant (Dahlby and Warren, 2004).

[14]The formulae are based on real-world formulae, though real-world formulae generally also adjust for differences in the cost of providing public goods (called "cost equalization"), due either to higher costs of providing the services (e.g. roads in rural areas) or due to greater demand (e.g. social services in urban areas). Resource equalization tends to be biased to rural areas, where there is less total income, while cost equalization tends to be biased to urban areas, where there is more demand for public services and wages are higher. Real-world grants can also account for externalities between geographic units. In this model, with no externalities and no differences in the cost of providing public goods, these adjustments are unnecessary. Real-world equalization is also influenced by political factors like local governments' party politics and bureaucracy, dynamics which are excluded entirely from this model (Johansson, 2003; Meyer and Naka, 1999; Grossman, 1994).

[15]A "tick" corresponds to a time step in which all households have one chance to move and to vote. This model never settled into a micro-level equilibria within 50,000 ticks. In contrast, macro-equilibria consistently occurred around the 5,000th tick. By "macro-equilibria" we mean that tax parameters, public goods provision, the distribution of population density across jurisdictions, and preference and economic segregation stabilized. Looking at income segregation, at the first time step the average income in the richest jurisdiction is about 60,500, compared to the middle jurisdiction of about 60,000 and the poorest at about 59,500, a random spread of 1,000. Every simulation run begins with significant segregation such that by about tick 700 segregation reaches its maximum level, which can be a spread of as high as 6,000. By tick 4000 segregation recedes and stabilizes. Housing prices converge more slowly than all other macro characteristics, because the price was initialized at 0. Sampling a few experimental conditions for runs of 30,000 ticks, housing prices reach 2/3 of their final prices by the 5,000th tick, although the relative cost of housing by jurisdictions ranked by mean income were stable as of about tick 200 and all other macro characteristics were also stable. As such, the presented results use simulations run for 5000 ticks.

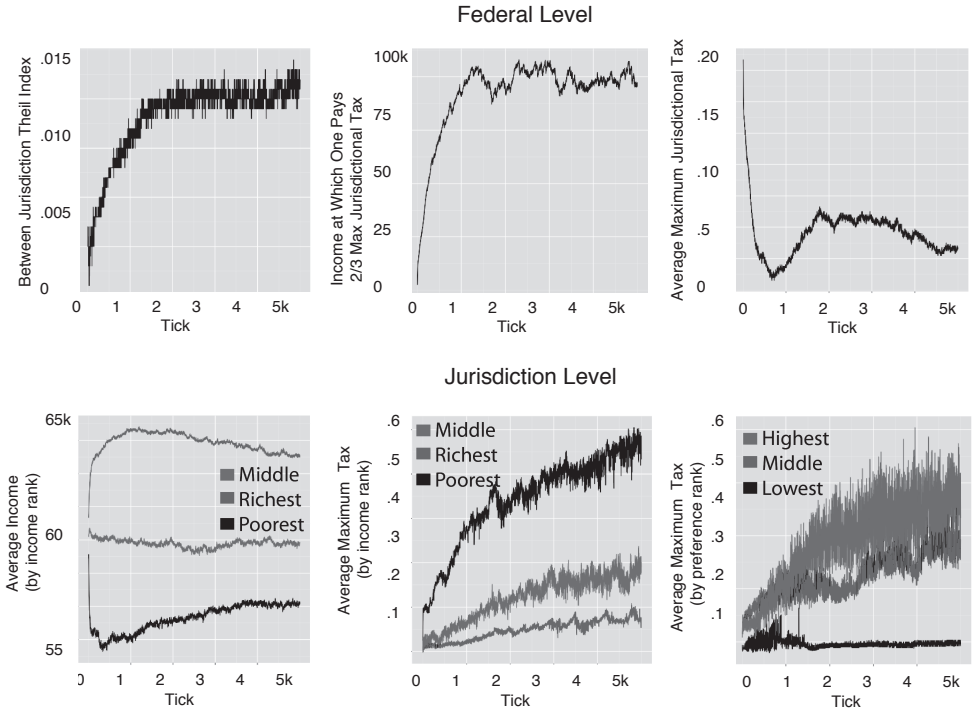

Figure 3: Model convergence as measured by stabilizing segregation and tax rate parameters

jurisdictions with the lowest preference for public goods had a maximum rate of about 20% while those with the highest had an average tax rate fluctuating around 40%.

3.0.6. Validation

One way to validate the model is to compare the parameters for the tax curves produced by the simulation with empirical parameters. Switzerland's direct democracy is very close to a median voter model (Feld and Kirchgssner, 2000) and has a horizontal equalization system (Dafflon, 2014), and as such should be compared with the simulation using a median voter model with moderate horizontal equalization where federal taxation is not fungible. This model produces a pattern of taxation very close to the Swiss case. The simulated jurisdiction maximum tax ranges from .25 to .40 compared to the values of .12 to .29 which were found when fitting cantonal tax tables. In the model, the correlation between jurisdiction's mean per capita income and the maximum tax rate is -.433, compared to -.478 in the Swiss data.[16] The income level at which a household pays 2/3 of that maximum rate is also similar, ranging from 62,885 to 246,879 CHF in the simulated jurisdictions compared to 84,835 to 299,349 CHF in the Swiss cantons. In sum, based on tax and income data, we might say the simulation provides a good fit.

4. Results

The model varied three dimensions: equalization type, the extent of equalization, and the voice mechanism. There were four types of equalization: pure federalism, horizontal equalization with federal per capita grants,

[16]Data taken from 2007 tax tables, income data from Steuerverwaltung (2014).

vertical equalization, and horizontal equalization with no federal taxation. Within each equalization scheme, the extent of equalization was varied from 0 to 1.0 in .1 increments. Finally, each of these was run using two voting mechanisms: the median voter model and the utility-weighted voting scheme. In total there were 68 experimental settings with 10 runs per setting.

4.1. Fiscal Federalism

4.1.1. The fiscal externality problem emerges

The fiscal externality problem means that in a population of mobile households with heterogeneous incomes, the wealthy will cluster in low-tax jurisdictions. In the simulations of pure fiscal federalism, this pattern evolved. The first two columns of Table 2 show the ratio between the simulated income gap between the single richest and single poorest jurisdictions to the income gap when residence is randomly assigned. (The expected gap is not zero, because the income distribution is extremely skewed and there are a limited number of jurisdictions and lots. This means one or two extremely rich agents, will land at random in a given jurisdiction generating a non-zero gap.) The second two columns show the ratio between the gap in average preferences for public goods between the the single most and single least public-good-loving jurisdictions to the gap that would randomly occur (again because of small numbers). Focusing the first row, which is the case without equalization, we can see that there was significant economic segregation in both the median voter model as well as the utility-weighted voting model. In addition there was significant preference segregation (i.e., Tiebout sorting).

Table 2: Ratio of Actual Versus Random Income and Preference Gaps

	Economic Segregation		Preference Segregation	
	Median Voter	Utility-Weighted	Median Voter	Utility-Weighted
Pure federalism	1.50	4.96	3.00	6.00
Horizontal (w/ fed)	1.03	2.90	1.00	3.70
Vertical	1.14	3.19	1.05	4.15
Horizontal (no fed)	1.76	5.50	3.05	5.95

The second piece of evidence necessary to confirm that the model generates a fiscal externality problem is the tax rates that emerge out of the model. The left-hand panel of Figure 4 shows the tax curves for the single richest and poorest jurisdictions, averaged across the ten fiscal federalism models without equalization, using the median voter model. The right-hand panel shows the same, but using utility-weighted voting. Income is on the x axis and tax rate on the y. We can see that generally the richest jurisdiction has lower, flatter, tax curves than the poorest. In the median voter model, the the average person has more voice and segregation is lower, so taxes in the richest jurisdiction are more similar to those in the poorest. In the utility-weighted voting model, where the wealthy have more voice and are more segregated, the taxes in the richest jurisdiction are significantly lower and flatter.

In sum, the computational model, as expected, confirms that fiscal federalism with progressive taxes and a heterogenous population results in the fiscal externality problem. We can conclude with very strong support for hypothesis *H1a: Fiscal federalism with local progressive taxation generates residential segregation, sorting by preferences, and inequitable public goods provision.*

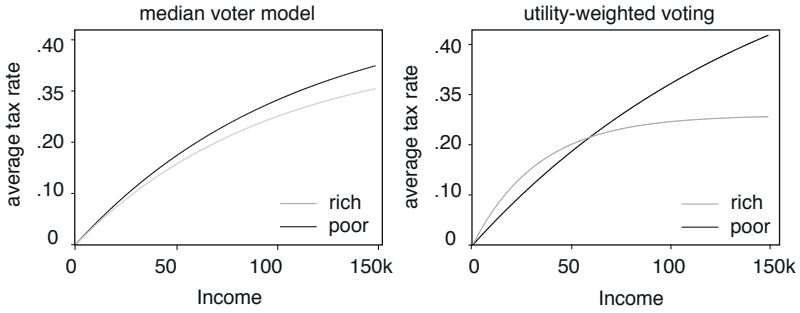

Figure 4: Simulated tax curves for pure fiscal federalism models

4.1.2. With utility-weighted voting, public goods provision is more efficient, but also more inequitable

There are three key pieces of evidence necessary to understand how the fiscal externality problem differs between the two voting models: the level of segregation (set through exit), the chosen tax rates (set through voting), and then the resulting distribution of public goods. Looking at the first row of Table 2, we can see that economic segregation is systematically higher when the rich have more political voice. This would imply likely losses in the equity of public goods provision. We can confirm that there is a problem with equity, looking back to Figure 4, which shows that wealthy jurisdictions enjoy much lower and flatter taxes, particularly with utility-weighted voting. The consequence is a very strong chase-the-rich dynamic, where average agents benefit by moving into wealthy jurisdictions. It is for this reason that in the richest jurisdiction the average population density is 610 agents over 625 lots, compared to just 536 in the poorest jurisdiction. At the same time, utility-weighted voting seems to also be associated with more Tiebout sorting. Table 2 shows that with utility-weighted voting the preference for public goods in the single most public-goods-loving jurisdiction is 6-fold the preference in the single least public-goods-loving jurisdiction. Figure 5 illustrates per capita public goods for jurisdictions ranked by their average public goods preferences. The black lines highlights the case at hand, with the grey dots in the background illustrating results from all other experiments. We can see while there is some evidence of efficiency gains in the median voter model, in models with utility-weighted voting, there is an even greater difference between the level of public goods in those areas that prefer them to those that do not. In sum, there is evidence that pure fiscal federalism, particularly with utility-weighted voice, manifests both positive Tiebout sorting as well as the negative fiscal externality problem.

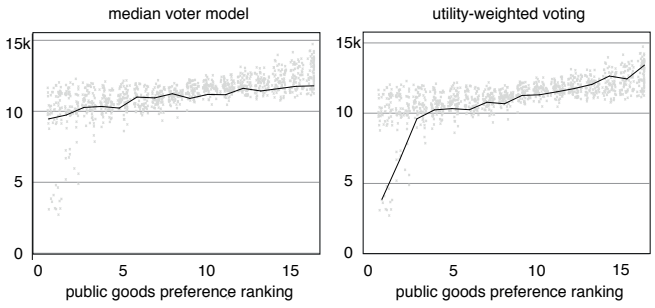

Figure 5: Per Capita Public Goods (by jurisdictions public goods preference)

The most important model outcome is utility. Figure 6 shows the mean utility by jurisdiction, ranking the jurisdictions by income. The lines highlight the utilities for the experiment at hand, while the dots in the background indicate the values from all other experiments. We can see that with pure federalism and a median voter model, utilities are low, and somewhat inequitable, while with utility-weighted voting, all utilities are higher, but inequality increases. This is consistent with the finding that there is more preference *and* income segregation with utility-weighted voting. We can conclude that utility-weighted voting is both more efficient and inequitable, confirming the first part of our original hypothesis but contradicting the second part, (*H1b: With utility-weighted voting, public goods provision is more efficient, and equally equitable*).

In conclusion, we can say that the baseline model of fiscal federalism was able to confirm our expectation that progressive taxation under fiscal federalism generates both Tiebout sorting and the fiscal externality problem. The new utility-weighted voting mechanism enhances both effects.

4.2. Equalization

The primary goal of this paper is to test whether equalization can improve the fiscal externality problem. Experiments were run under four scenarios: no equalization, horizontal equalization with federal taxation, vertical equalization, and horizontal equalization without federal taxation. Each of these, in turn was run with the two voice mechanisms: the median voter model and utility-weighted voting.

4.2.1. Overview of results

Table 3 provides an overview of all the tested cases and their outcomes. Within each cell (except those cells without equalization) there are experiments using 10 different settings for the equalization parameter (with 10 experiments per setting). The first and fourth columns highlight the two models of pure federalism discussed in the prior section. If we recall, in the median voter version of pure fiscal federalism, there was significant preference and income segregation, leading to both more efficient and less equitable public goods provision. As a result, utility levels were moderately high though significantly higher in the richer jurisdictions, and there was high population density in richer jurisdictions. All of these results were enhanced using utility-weighted voting.

Table 3: Scenario Summary

	median voter				utility-weighted vote			
	ff	hf	v	hNf	ff	hf	v	hNf
taxation moves to federal	NA	++	++	NA	NA	+	+	NA
income segregation	+	0	0	+	++	+	+	++
preference segregation	+	0	0	+	++	+	+	++
progressive taxes	−−	+	+	−−	− − −	−	−	−−
unequal public goods	−	0	0	+	−−	+	+	0
efficiency	++	0	0	+	+	++	++	+
utility level	0	0	0	−	+	++	++	+
utility fairness	−	+	+	−	−−	−	−	−
migration counteracts policy	NA	0	0	+	NA	+	+	++

ff: pure fiscal federalism, hf: horizontal equalization with federal taxation, v: vertical equalization, hNF: horizontal with no federal taxation

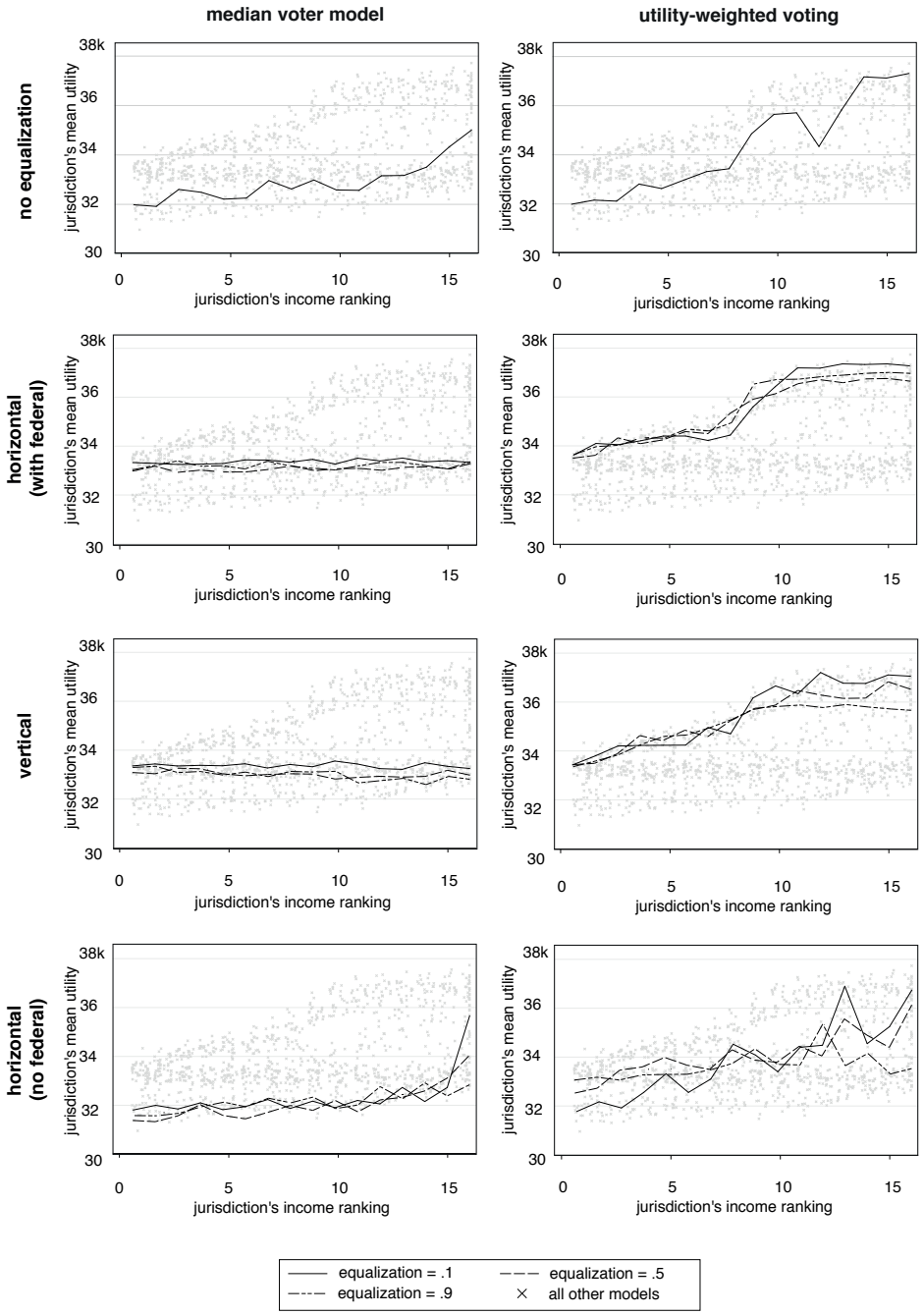

Figure 6: Mean jurisdiction utility by jurisdiction income rank

4.2.2. Agents eliminate fiscal federalism when they can

In Table 3, one notices immediately that the two scenarios with the median voter model and the option of federal taxation (*hf* and *v*) have the same results, and that these results differ dramatically from all other scenarios. In these two cases, there is no income or preference segregation, taxes are progressive, and public goods are provided equally across the population. These results are easily explained by the fact that in both of these models the agents opted for centralized taxation. Figure 7 shows the total level of taxation, split between local and federal in the 4 main models (averaged across the different levels of equalization). The dominance of the large grey areas in the models with federal taxation, show that when possible, agents choose to shift most taxation to the federal level. Under the median voter model agents shift a full 97% of total tax burden to the federal level compared to 89% with utility-weighted voting. The two models are not, however, exactly the same. In the horizontal model, grants are passed down to jurisdictions on a per capita basis, while with the vertical scheme, grants are based on tax capacity. This difference manifests itself in the model dynamics. In the vertical scheme the agents flee the wealthy, while in the horizontal they are ambivalent. Centralizing taxation is a smart strategy for the average agent, eliminating the fiscal externality problem. However, the simple agents do not recognize that fact. Rather, agents eliminate federalism in an incremental manner. When the federal government proposes a rise in taxes, the average agent approves it because it increases their public goods consumption more than their taxes. The agent's willingness to accept a rise in local taxes then declines, as their demand for public goods is satiated by the federal government.

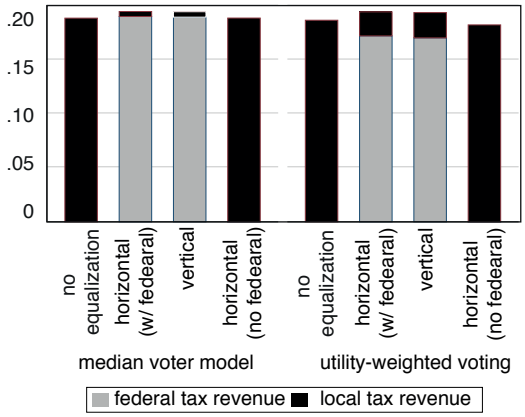

Figure 7: Distribution of tax burden

4.2.3. Pareto and Rawlsian optimum occur when agents shift most (but not all) revenue collection to the federal level

There are four scenarios in which equalization plays an important role: horizontal equalization and no federal taxation under both voting models, as well as the two equalization schemes with the possibility of federal taxation with utility-weighted voting.

The best results are from the horizontal and vertical equalization models with utility-weighted voting. In the summary table we see that both models have significant economic and preference segregation, regressive taxation, and unequal public goods provision. Figure 8, focuses in on the equity-efficiency trade-off. The first panel shows the level of public goods in each jurisdiction, with jurisdictions ranked by their average public goods preference.

Those jurisdictions with higher public goods preferences have more public goods—clear evidence of Tiebout sorting and efficiency gains. The second panel shows the average applied tax rates by jurisdiction. In both models about 11% of revenue collection remains local, with the poorer poorer jurisdictions levying higher taxes. The correlation between mean jurisdiction income and the effective tax rate for the mean earner is -.77 in the horizontal (with federal) model compared to -.79 in the vertical model—significantly regressive. If we look back to Figure 6, showing jurisdictions' average utilities ranked by jurisdiction income, we see that in the richest and poorest jurisdictions utilities are extremely high, with *both* the poor and the wealthy jurisdictions both achieving their possible highest utilities among all experiments, although there is significant inequality between the wealthy and the poor jurisdictions' utilities. In sum, these two models lead to a Pareto, as well as Rawlsian, optimum. The poor achieve their highest possible welfare, though there is a substantial level of inequality.

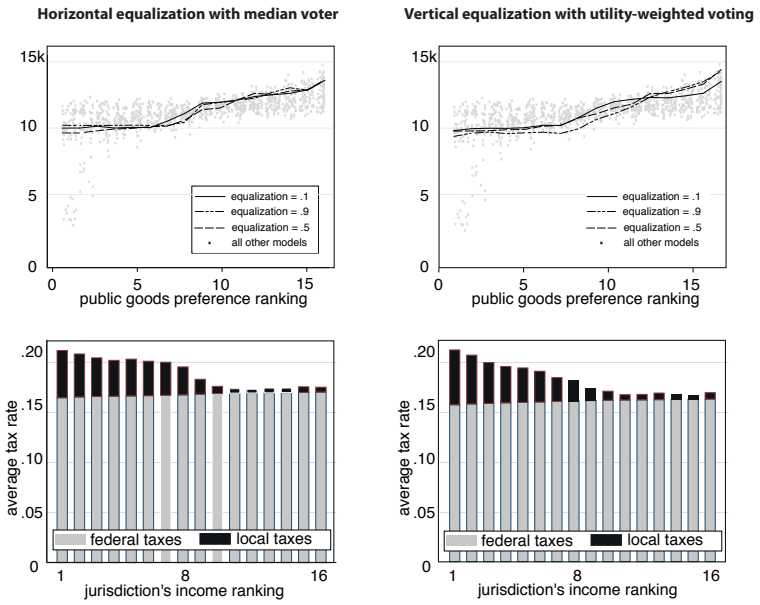

Figure 8: Equity (per capita public goods by jurisdiction's public goods preference) and fairness (applied tax rate by jurisdiction's income)

The last two equalization scenarios are the two models with horizontal equalization but no federal taxation. These two models are broadly similar. Looking back at Table 2, we can see that both preference and economic segregation are higher with utility-weighted voting, yet given the chosen tax rates, the utility weighted model has somewhat fairer taxation with a correlation between mean jurisdiction income and the effective tax rate for the mean earner of -.35 in the median voter model versus -.11 in the utility-weighted version. In the median voter version utilities are extremely low—the lowest of all tested models and there is some inequality, with higher utilities in wealthier areas. In the utility-weighted version, utilities are a bit higher, but somewhat more unequal. We might say that both horizontal equalization models with no federal taxation are rather poor solutions to the fiscal externality problem, failing to significantly improve income segregation and inequitable goods provision, and at the same time, failing to tap into Tiebout sorting's efficiency gains.

4.2.4. Equalization policy is undermined by micro agents' actions

Up to now we have grouped together results, ignoring the extent of equalization. The reason for this is that, surprisingly, the extent of equalization has little effect. If we look back at Figure 6, which showed jurisdictions' mean utilities by income rank, we notice that the three lines indicating low, middle, and high equalization barely differ. In the two median voter models where agents centralized taxation, of course, we expect flat lines with equalization having no effect. However, even for the remaining figures, equalization has at most a weak effect, slightly reducing the average utility in the wealthiest jurisdictions, but having no effect on the poorest.

The reason for this is that increasing equalization is counterbalanced by population shifts. In absence of equalization, rich jurisdictions are more attractive because of their higher level of public goods. However, when equalization increases, the local tax effort is redirected to fund public goods in poorer jurisdictions. This makes low-income jurisdictions more attractive, and at some point the population shifts from following the wealthy to fleeing them. Figure 9 shows the mean income in the highest and the lowest population jurisdiction in two models: vertical equalization with a median voter model and horizontal equalization (with federal taxation) in the utility-weighted model. In both models, as equalization increases, the highest population jurisdiction shifts from being wealthier than the lowest population jurisdiction, to being poorer. The tipping point varies across models. It is between .2 and .3 in both vertical equalization models as well as in the model with horizontal equalization (with federal taxation) and utility-weighted voting. The tipping point is between .7 and .8 in the two models with horizontal equalization and no federal revenue collection. In sum, migration counteracts equalization policy, providing clear support for *H2a: Equalization can only partially mitigate the negative side effects of fiscal federalism, as micro-actions can likely undermine policy*.

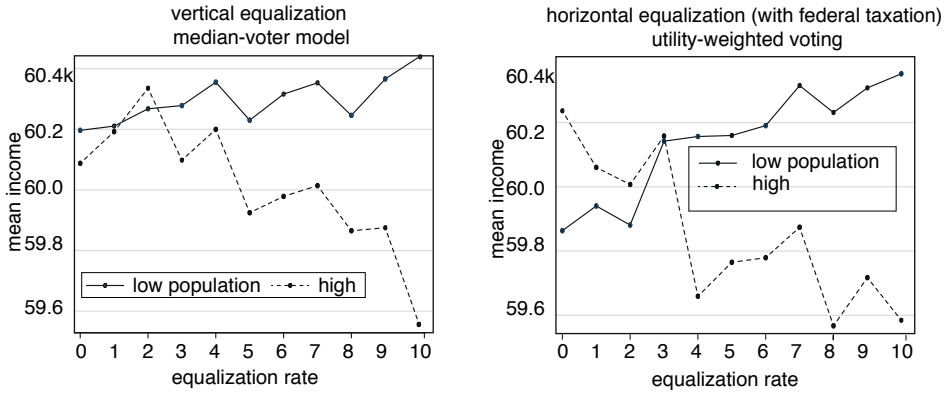

Figure 9: Mean income in high and low population jurisdictions by equalization rate

The fact that migration counteracts policy is closely related to our fifth hypothesis, *H2c: Equalization improves equity more under a median voter model*. This hypothesis could not be tested under those models with federal taxation and a median voter rule, because the agents abandoned fiscal federalism all together. However, the two models with horizontal equalization and no federal taxation can be compared. There is essentially no gap in public goods provision using high versus low equalization under both voting mechanisms. The reason for this is that equalization's impact is channeled exclusively into housing prices and population density. As equalization increases, the price gap between high and low income jurisdictions flips and then grows, as does the gap between mean incomes in the highest and lowest population jurisdictions. In other words, increasing the extent of equalization impacts migration and housing market prices, but not equitable public goods or progressive taxes—

equalization's the main targets. In sum, because of the fact that micro-dynamics undermine equalization policy, we can reject hypothesis H2c; the voting model does not interact with equalization's impact, because equalization itself does not matter.

4.2.5. Vertical equalization does not consistently engender over-spending in poor jurisdictions and horizontal equalization does not engender under-spending in wealthy jurisdictions

Based on the empirical literature on vertical and horizontal equalization, we hypothesized that horizontal equalization could incentivize under-spending in rich jurisdictions, while vertical equalization could incentivize over-spending in poor jurisdictions.

Starting with horizontal equalization, there is evidence that utilities in wealthy jurisdictions decline with increasing equalization, but *not* because of declining public goods provision. With increasing horizontal equalization, public goods provision in wealthy and poor jurisdictions do not change at all. There are, instead, two other reasons for this decline in utility. First, as equalization increases, taxes increases slightly in wealthy jurisdictions, decreasing utility. Second, and more importantly, as equalization increases, housing prices in the wealthier jurisdictions increase, decreasing utility. Under horizontal equalization with federal taxation, the 5th wealthiest jurisdiction experience housing price increases, while the rest experience decreases. Under horizontal equalization without federal taxation the 10 wealthier jurisdictions experience price increases while the rest experience decreases. In sum, increasing horizontal equalization does not lead to a decline in public goods in wealthy jurisdictions, though it does lead to declines in utility, due to increasing taxes and housing prices.

There is mixed evidence as to whether generous vertical equalization encourages public goods spending in poor jurisdictions. With utility weighted voting, when vertical equalization increases from minimum to maximum levels, the single poorest jurisdiction increases public goods spending by 1343 CHF per household, but using the median voter rule, public goods spending actually *drops* by 257 CHF per household. [17] The reason for this asymmetry likely has to do with segregation. In the utility-weighted model, there is more economic segregation. The poor jurisdictions are more likely to suffer from scarce resources, so federal grants increase spending. In contrast, in the median voter model, segregation is very low; poor jurisdictions are not very badly off, and so grants displace local spending rather than augment it. Given the mixed evidence for equalization distorting spending, we fail to accept *H2b: Increasing horizontal equalization will reduce wealthy jurisdictions' public goods provision and utilities, while increasing vertical equalization will increase public goods provision and utilities in poorer jurisdictions.*

5. Conclusion

This paper examined a model of fiscal federalism with equalization. The work built on the multi-community literature by incorporating the best aspects of model design, including using heterogeneous agent incomes and preferences based on empirical distributions, and incorporating an endogenous housing market with limited housing stock. We also added to the exiting literature by examining a context with progressive taxation, and by examining not only the traditional median voter model, but also a new utility-weighted voting model.

We hypothesized that pure fiscal federalism should lead to residential and preference segregation, which we con-

[17] The direction is the same in the richest jurisdiction, which increases public goods spending under the utility-weighted voting by 548 CHF as equalization increases, but drops public goods spending by 332 CHF in the median voter model.

firmed. We also hypothesized that with utility-weighted voting, public goods provision would be more efficient and equally equitable, but found evidence that it is more efficient and *more* inequitable. Looking at equalization policy, we found that equalization's potential was largely undermined by micro-agents' residential choices and the housing market. We also hypothesized that equalization could introduce more equity under the median voter model. We did not find evidence of this, largely because agents' micro-actions undermined equalization in the first place. Finally, in examining the anticipated negative consequences of horizontal and vertical equalization (in terms of over or underspending on public goods), we found mixed evidence, largely because the expected effects were undermined by micro-actors' choices and resulting economic segregation, housing prices, or tax levels. In sum, we found that equalization can be a very unpredictable tool in a dynamic world.

Among the models tested, two best-case scenarios emerged. Under utility-weighted voting models with horizontal equalization (with federal taxation) or vertical taxation, agents shifted most taxation to the federal level with only some jurisdictions levying a small local tax. This combination of primarily central taxation with minor local taxation allowed for both increases in overall efficiency via Tiebout sorting, as well as less equitable public goods provision. These scenarios generated results that are optimal from a Rawlsian perspective, as the utilities of the worst-off were higher than in all other models, including pure centralized funding, although still not as well-off as the wealthiest. The implication seems to be that in an environment with economic inequality and progressive taxation, perhaps only minor revenue collection should be left at the local level.

This paper is the first in the multi-community literature to consider progressive taxation and an alternative to the median voter model while studying equalization policy. There are several expansions of the model that should be considered in the future. First, it is important to understand how loyalty, or a lack of residential mobility) would change results. Prior research suggests that equalization might have more potential when the population is less mobile, though this has not been investigated under progressive taxation. A second potential expansion would be to consider diverse public goods, to allow the possibility for greater preference sorting and efficiency gains. A third expansion would be to consider jurisdiction size. Using a skewed income distribution with 16 equally sized jurisdictions, the rich could never hold majority voting power under the median voter model. One might hypothesize that by reducing jurisdiction size, the median voter experiments might potentially look more like the utility-weighted voting, or by increasing jurisdiction size, utility-weighted voting might look more like the median voter model. That said, other research to date has found little effect of jurisdiction size (Calabrese et al., 2012). Finally, we might think about extensions with respect to empirical data integration. While the model was validated with the Swiss case, and we argue that these findings should be generalizable, it is nevertheless important to confirm that these dynamics also occur under other tax schemes, such as the UK's discontinuous property tax bands. It could be the case that using the UK's discontinuous council taxes, compared to the continuous Swiss income taxes, the dynamic system could settle into mid-point equilibria, perhaps with less segregation.

In conclusion, we have illustrated that there are significant challenges to managing an equitable and efficient taxation system under fiscal federalism, and that policies like equalization are significantly limited because of the potential for micro-agents actions to undermine policy. Looking at the best-cases, results seem to suggest fiscal federalism should not be entirely eliminated nor corrected by equalization, but rather dramatically limited. We would suggest further research to understand how loyalty impacts these dynamics, and to confirm that these dynamics hold under conditions specific to other contexts.

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A. Online Appendix

We would like to make the java code for the simulation available on-line.